Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 47 (2012) 93 – 97

Procedia
Social and Behavioral Sciences

CYICER 2012

# Application of genetic algorithms in stock market simulation

Jiří Štěpánek*[a], Jiří Šťovíček[a], Richard Cimler[a]

[a] University of Hradec Králové, Rokitanského 62, Hradec Králové 50003, Czech Republic

**Abstract**

Development of stock market is affected by many factors. It is difficult to predict changes in prices of stocks because of many parameters in behavioral algorithms. There is also problem with learning soft-skills because of many variables. Application of genetic algorithms can help find suitable pre-set of behavioral patterns, functions and its parameters. In this paper we describe creation and implementation genetic algorithms to existing multi-agent simulation. This existing simulation provides basic model of simulation of stock market members behavior. The main goal of this article is describe how to implement genetic algorithm into this type of simulation. The main advantage of using genetic algorithms is dynamically created decision process or function of each agent. Article describes process of creating decision, simulating behavior of agents which decision algorithm was created by genetic programming. Next point is to show, how can be this implementation of genetic algorithms used in learning process of simulation.

*Keywords:* evolution algorithms, genetic programming, multiagent simulation, stock-market

## 1. Introduction

The aim of this research is a creation of a program simulating behaviour of stock market participants based on psychological analysis using genetic programming and multi-agent approach. We can consider participants as persons trying to maximize their profits using a short-time fluctuation of stock prizes. There are a few basic facts on which we can build our model. Every participant has different characteristics, there is volatility of stock prices on market, stocks are considered as homogeneous commodity and it is empirically acknowledged hypothesis that distribution of profits is nearly normal. (Suhadolnik, 1998) Genetic algorithms are used for finding decision function of participants which will closely imitate real behaviour of stock market participants.

* J. Štěpánek
*E-mail address*: jiri.stepanek@uhk.cz

 doi:10.1016/j.sbspro.2012.06.619

## 2. Stock market

On the stock market different kinds of stocks are trade. In this research we focus on one of that kind – shares. Every participant is entering market with his own funds and is trying to maximize his profit by buying and selling shares. Dividends and shock market fees are not taken in account in this paper. Price of shares of new company on market has its fundamental value. After first business this price depends only on offer and demand. Price of share is equal to value of that share in last realized business. Based on development of stock price participants are buying, holding or selling shares. For sake of simplicity we consider only two possible actions of shareholders. Every turn shareholder has to decide to buy or sale share. There are few basic approaches for choosing strategy of participants on real markets. There are three types of analysis: Fundamental analysis, technical analysis and psychological analysis.

### *2.1. Analysis*

Fundamental analysis deals with characteristics of company such as financial results of company, stability of company management, account sheets, political and economical environment, confrontation with results of other companies in branch and many other characteristics. In this paper we don't use this type of analysis because we consider share as homogeneous product with no connection on particular company. Technical analysis is based on observation of historical development of stock prices, statistical methods, moving average etc.. This paper handles with last of this tree types – psychological analysis. Psychology analysis deals with human decision making process based on information gained from available environment. This environment is composed of other traders who could observe each other. Their behaviour gives information to other traders about their strategy and about effect of stock price on their behaviour. With this information traders could be able to partially predict development of stock prices and choose their actions. In real systems trader doesn't have all information about other traders. Trader's information is always limited thus in simulation trader has information only about his near neighbours.

### *2.2. Simulation*

Described system of stock market is simulated in multiagent-system. Each trader is represented by autonomous agent and has his own characteristics. Due to these characteristics agent decides which action he will perform in his next step. Even agents have same goal to maximize their profit, every agent could have different behaviour because of their different characteristics and also different information of close environment. Agents are organized in two-dimensional field. As close environment we consider 8 surrounding agents – neighbours. Agent decision is affected by his preferences, price of share and due to actions performed by neighbours. Absolutely correct algorithm of trader's behaviour can't be programmed. Aim of this research is to find algorithm describing traders behaviour enough accurate. Genetic programming (GP) has been chosen to help finding these algorithms. GP provides procedures for finding such algorithms which describes traders behaviour on the stock market enough accurate.

## 3. Creating of simulation

Model was inspired by (Suhadolnik, 1998). In this model agent is characterized by a few attributes such inclination to risk or suggestibility by its neighbours etc. Each agent has different values of this attributes and that makes him unique.

Shares are homogeneous and its price depends only on count of buyers, sellers and price in last iteration. Due to his own information and attributes agent decides if will buy or sell shares. Holding shares is not considered in this model. Decision function is created by GP procedures and distribution of profits should mount to normal distribution.

### *3.1. Core of model*

In the beginning of simulation evolution algorithm creates group of programs – parse trees. Fitness function rate these parse trees according to their fittingness for solving problem. Couples of programs are chosen and crossed in purpose to find program solving this situation better. There are few steps in counting fitness function. Decision function is generated and implemented to agents before start of each simulation. Decision function is algorithm which chooses behaviour of agent according to information which he has. In the end of simulation, profits and losses of all agents are analyzed. Statistical methods are used to compare distribution of agent's profits to normal distribution. According to resemblance distribution in modelled situation to normal distribution, decision function is rated. Statistical function Pearson's chi-square test(Skalská, 2003) is used for this analysis. If resemblance between distributions is enough good, program successfully ends.

### *3.2. Initiatory population*

Initiatory population is a set of randomly generated parse trees. In our application is possible to set maximal deepness of generated parse tress(Koza, 1992). In our case parse tree represents decision function and size of Initiatory population. Generateor chooses between a few types of nodes: operator, constant, variable, mathematical function. Parse tree is created from these nodes and is used as the agent's decision function.

### *3.3. Crossing*

Initiatory population is a set of randomly generated parse trees. In our application is possible to set maximal deepness of generated parse trees(Koza, 1992). In our case parse tree represents decision function and size of Initiatory population. Generator chooses between a few types of nodes: operator, constant, variable, mathematical function. Parse tree is created from these nodes and is used as the agent's decision function.

Multi-agent system (MAS) is a system composed of autonomous units called agents. Agents can interact with each other and they can also interact with environment of system. There are a few basic characteristics of the MAS. Agents are **social** that means they can communicate with each other. Ability to react on the changing environment makes agent **reactive**. Although agents are designed by human they make their own decision according to their plans: we say that agents are **autonomous.**(Cimler, Ponce, 2010) Agents have limited information about environment where they act. They have only information gain by their sensors. One of typical characteristics of MA is decentralization which means that in MA is no central unit leading whole system.

Multi-agent simulations are used to model difficult situations which can't be solved by analytical methods. Using MA simulations have many advantages. It can be used for simulation complex systems and they are very flexible to changes in their presets.

Our simulation is composed of 10 000 agents organized in two-dimensional square shape environment with length of edge 100 agents. Basic characteristic of each agent is his inclination to be affected by decision of its neighbours instead of making his own conclusions. This attribute is called Mi.

*3.4. Multiagent system – decision making*

In the beginning of simulation agent's decision function (as a result of GP procedures) is set. Particular values for every agent are set during each iteration into this function. These values are gained from environment of agent (count of neighbours-buyers etc.) Agents decide about their next step due to results of their decision function. Final result is not deterministic so the result is transformed to number between 0 and 1 by logistic transformation.

Random number from interval 0 and 1 with uniform distribution is generated and compared with transformed result. Result of comparison set next action agent action. Share price changes every iteration, see Formula 1.

$$R_t = \ln P + (1 - \ln P(t))$$

Formula1.: Shares changing formula

Where P is share price and t is iteration number. In simulation share price is counted in few steps:

1. *bt* variable is set up:

$$bt = \frac{buyers\ agents - sellers\ agents}{Total\ amount\ of\ agents}$$

Formula 2.: bt variable

2. correction coefficient is set up:

$$1 + \frac{e^{bt} - e^{-bt}}{e^{bt} + e^{-bt}}$$

Formula 3.: Correction coeficient

3. Share price of last iteration Is multiplied by result of step 2.

In step 1 count of buying and selling agents in last step is used. This algorithm changes price of shares due to number of buyers and sellers. If there is many buyers price of shares will rise and conversely.

## 4. Conclusions

The importance of simulations in education is still increasing. The real-life processes can be simulated over and over, many times, can be speeded up, slowed down, paused or run concurrently in many instances at the same time. This allows us to analyse systems independently on the time, test new approaches with no risk and cooperate on tasks in virtual teams. One of systems suitable for this kind of simulation is a stock market. There are many applications providing the possibility of technical and fundamental analysis. We focused our research on the use of multiagent simulation of the stock market based on a psychological analysis. In real world stockjobbers are consciously or unconsciously influenced in their decision making by accessible information from media, analysts and another stockjobbers actions. Genetic programming was used to achieve the good-enough result of a stockjobber agent behaviour approximation. The system allows us to analyse causal dependencies, compare efficiency of different strategies and provides the wide scale of future expansion possibilities. Our aim is creating the complex stock market simulation with public interface for updating new programs simulating the behaviour of the trader. The system will evaluate each agent behaviour every day on a real stock market data and provide the feedback.

Contributors will be able to see programs ordered by their efficiency, share ideas and combine their programs to acquire even better results.

## References

[1] HYNEK, J. (2008) *Geetické algoritmy a genetické programování* Grada
[2] KOZA, J.R.(1992) *Genetic Programming: On the Programming of Computers by Means of Natural Selection* MIT Press
[3] SKALSKÁ, H. (2003) *Statistika, analýza dat a znalostní management*
[4] SUHADOLNIK, N., GALIMBERTI, J, DA SILVA, S. (2011) *Robot traders can prevent extreme events in complex stock markets* Retrieved from: http://mpra.ub.uni-muenchen.de/23923/1/RobotTradersCanPreventExtremeEventsInComplexStockMarkets.pdf
[5] CIMLER R., PONCE D (2010) *Solving queuing theory problems using multiagent systems* Conference proceedings MME2010